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SIMPACK News

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Jordan EJ15 at the USA GP

SIMPACK Use at Jordan Grand Prix

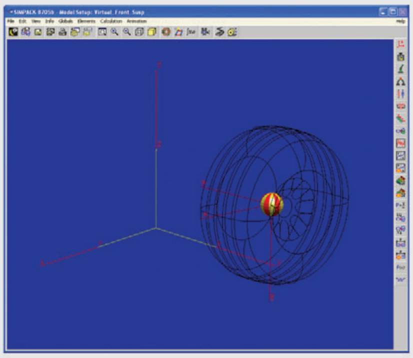
For a small Formula One team such as Jordan Grand Prix, dynamic simulation tools, in particular SIMPACK, are increasingly helpful in understanding the effects of design changes prior to track testing.

Track testing of performance parts has become much more a validation process than a learning process, and unproductive development 'paths' can be avoided through effective CAE work using the latest MBS techniques.
Jordan, (to be re-named Midland F1 by mid-November) has been using SIMPACK for just over 18 months. Despite the steep learning curve associated with using any MBS software tool, there have already been a number of SIMPACK- led developments on the car. More importantly the work undertaken has enabled the Vehicle Dynamics group to understand more fully the areas of tyre use and suspension kinematics and compliance effects, and to feed this knowledge into the design process.

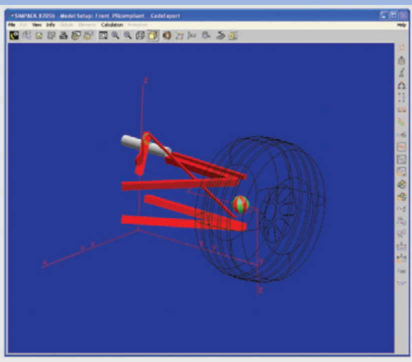
MODEL ARCHITECTURE

All models share a common chassis substructure, which possesses the mass and torsional stiffness properties of the monocoque, engine and gearbox, as measured by rig testing. The suspension substructures are split into three groups, rigid suspension geometry, compliant geometry and virtual suspension geometry. The latter utilises a Virtual Suspension Table (Joint Type 94), to implement the kinematics and compliance from a series of look-up tables. This can be particularly useful for testing kinematic characteristics in isolation. Virtual Suspension models also have the advantage of being particularly fast to solve, due to the lack of constraints in the suspen-

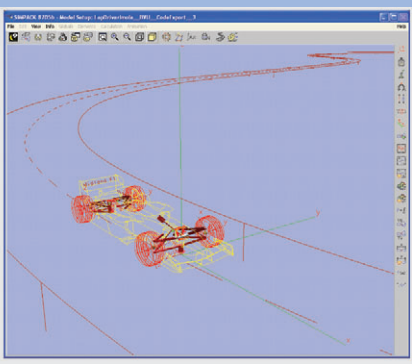
Richard Frith,
Jordan Grand Prix



Virtual Suspension Corner Model



Standard Suspension Corner Model



Lap Driver out on Circuit

sion sub-system. The fact that virtual suspension models can be solved by ODEs rather than DAEs (as with a constrained model), is particularly useful when linking models to Simulink (see Code Export below).
Accurately reproducing the aerodynamic forces and moments is fundamental to F1 CAE work. These characteristics are mapped from wind tunnel data as functions of dynamic air pressure and front and rear ride heights.
In addition to straight-line effects it is also possible to account for the sensitivity of the aerodynamic forces to vehicle yaw and steer, as the precise airflow direction and angle of the steered wheels can greatly influence the magnitude and distribution of the aerodynamic forces on the car.
Arguably the most critical part of the full car model is the tyre implementation. A close collaboration between Jordan and its tyre supplier Bridgestone over the past 12 months has helped the team gain a greater depth of understanding of the data supplied from Japan. As a result of this, tyre models have been developed which address some of the fundamental problems associated with replicating the characteristics of these complex components. In addition, validation processes between track test data and the CAE environment are in constant development.

STANDARD SUSPENSION GEOMETRY

The standard suspension geometry models each part of the suspension individually. This has the advantage that all the individual forces going through the suspension members (including internal components) will be calculated. As the models are fully parameterised, it is quick and easy to make small modifications to the geometry and study its effects. To predict the compliance effects of the suspension, the wishbones and other suspension members are modelled as flexible bodies using SIMPACK's FE-interface FEMBS. This provides an ideal model to calculate the overall compliance of the suspension, as this is not only a function of the stiffness of the individual suspension members, but also very much a function of the suspension geometry.

VIRTUAL SUSPENSION GEOMETRY

The virtual suspension joint type 94 is used to model the kinematics and compliance of a suspension using look-up tables. The kinematic data required is generated by performing a bump and steer sweep (in case of the front suspension) using the standard suspension models. This is done within the parameter variation module which automatically creates the required look-up tables in a SIMPACK format (afs-file). The compliance is taken from an R&D test and input as a function of contact patch loads. The resulting model is very quick and is suitable for real-time applications.

TEST TECHNIQUES

Using basic data taken from the car (Glat, Vcar and lap distance) it is possible to recreate the path followed by the car in SIMPACK, describing the track in the form of horizontal and vertical curvatures with camber, as a function of lap distance. Sensors are used that can measure the positioning of the car relative to the track as well as the deviation at certain preview distance. This is fed into a control model that will control the steering; engine and brakes enable the model to replicate an exact outing.
Alternatively tracks are defined using cartographic functions within the SIMPACK Automotive module. Full vehicle testing is performed on such tracks either by means of a closed loop path following steer controller or by open loop inputs, for example in the case of a step-steer analysis. Many of the tests performed are variations on industry standards and include j-turns, constant radius, constant acceleration, lane changes and swept steer manoeuvres.
Driver modelling techniques require a different approach, as the difficulty lies in driving the car at the limits of tyre performance. This capability is

Richard Frith,
Jordan Grand Prix

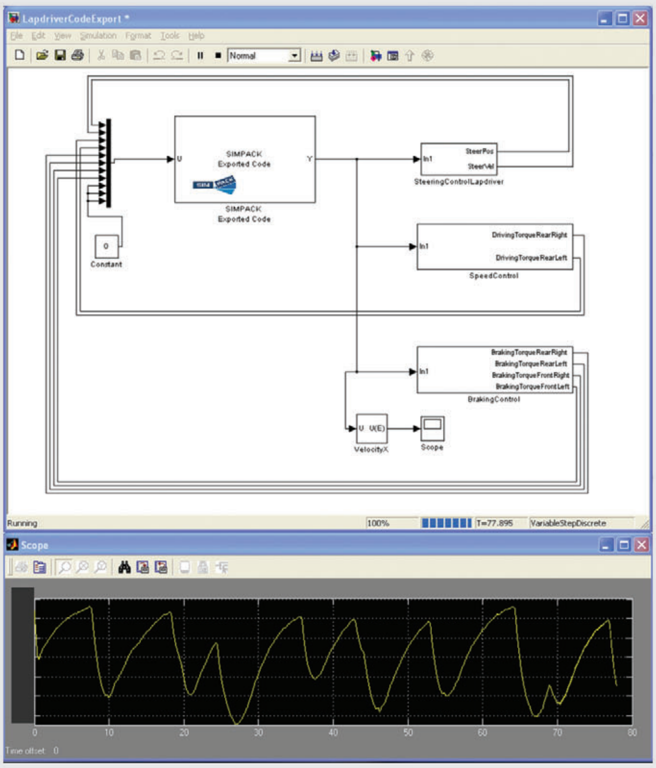
something that the Vehicle Science department is continually developing; the use of Code Export conveniently allows access to the comprehensive capabilities of Matlab and Simulink, an environment which the engineers are very familiar with. The outcome of this work brings with it great benefits in the assessment of performance as a lap time change, rather than as an improvement in more qualitative chassis metrics.

CODE EXPORT

Jordan has recently purchased the Code Export feature from INTEC, to enable models to be run as S-Functions in the MATLAB/Simulink environment. Code Export brings proven SIMPACK chassis dynamics models into a computing medium which is used in common by the chassis dynamics, control and race engineers. It not only gives the control engineers access to more detailed dynamic models for control system work specifically, but it also allows the chassis dynamics group to utilise the existing on-car control system code in ride and handling simulations.

THE FUTURE

The design for the 2006 car, known as the M16, has taken place in a relatively short time period due to the many changes and uncertainties that come with a change of team ownership. An MBS package with the capabilities to produce answers quickly and accurately has been fundamental to making design decisions quickly. With careful use of full-vehicle dynamic simulation tools such as SIMPACK, combined with a solid scientific approach to testing both at the track and in a CAE environment, the team is now optimistic of improving its pace relative to its main competitors in 2006.



Simulink Model Containing the Code Export S-function